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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/688,521	10/17/2003	Robert P. Meagley	ITL.1026US (P16713)	2105

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EXAMINER	
WALKE, AMANDA C	

ART UNIT	PAPER NUMBER
1795	

MAIL DATE	DELIVERY MODE
12/28/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)
	10/688,521	MEAGLEY ET AL.
	Examiner	Art Unit
	Amanda C. Walke	1795

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *01 October 2007*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1,3 and 6-12* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1,3, and 6-12* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 10/1/2007 has been entered.

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 1, 3, and 6-12 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hallock et al (6,582,891 or 6,709,807) in view of Verhaverbeke (2004/0198066).

Hallock et al disclose a process for reducing roughness from a surface of a patterned photoresist. The process includes exposing a substrate having the patterned photoresist thereon to a vapor, wherein the vapor penetrates into and/or reacts with the surface of the photoresist. The substrate having the patterned photoresist thereon is then heated to a temperature and for a time sufficient to cause the surface of the photoresist to flow and/or react with the vapor wherein the surface roughness decreases. Optionally, the substrate is exposed to radiation during the process to increase the etch resistance of the photoresist and/or facilitate the reaction of the vapor with the surface of the photoresist. There exists a need for a process for reducing the degree of edge roughness in patterned resist features without significantly affecting the critical dimensions of

the feature. It is desirable that the process be extendable to those photoresists used to pattern features less than 250 nm, i.e., photoresists optimized and sensitive for exposure to activating radiation at wavelengths of 248 nm, 193 nm, 157 nm and the like. Moreover, it is desirable that the process be amenable to reducing edge roughness in positive tone photoresists as well as negative tone photoresists. Importantly, the process should be economical, easily implemented and not dependent upon the source or causal factors of the edge roughness. Optionally, the process further includes exposing the photoresist to activating radiation for a time and energy sufficient to increase an etching resistance of the photoresist prior to, simultaneous with or subsequent to exposing the photoresist to the vapor. The radiation that is used to expose the photoresist has a wavelength in the ultraviolet range, x-ray range or includes electrons generated from an electron beam, or the like. The vapor can be selected from a material that is reactive or nonreactive during the process. Preferably, the vapor is generated from a material with a boiling point less than about 200 degrees C at standard atmospheric conditions. Examples of suitable non-reactive vapors include ketones and esters such as acetone, methyl ethyl ketone, butyl acetate, ethyl lactate and propylene glycol methyl ether acetate. In another embodiment, the process for reducing edge roughness includes exposing a substrate having a patterned photoresist thereon to a reactive vapor. The reactive vapor diffuses into the surface of the photoresist and lowers the glass transition temperature at the surface exposed to the vapor. The substrate is heated to a temperature and for a time sufficient to cause the surface of the photoresist to flow wherein-the surface roughness decreases. During the process, the patterned photoresist is exposed to an activating radiation prior to, simultaneous with or subsequent to exposing the substrate to the vapor wherein the activating energy reacts with the photoresist to generate a

compound. The vapor reacts with the compound and adds mass to the photoresist. The compound is reactive with the vapor and is preferably, a free radical, a photoacid generator, a photobase generator, or the like. The vapor may be reactive or nonreactive with the photoresist depending on the choice of material selected to generate the vapor. In the case of a non-reactive vapor, the vapor penetrates into the surface of the photoresist and is believed to lower the glass transition temperature (Tg) at the surface of the photoresist such that the surface Tg is lower than a glass transition temperature for a bulk of the photoresist. That is, the surface Tg is lower than the Tg for the photoresist that was not exposed to any vapor. Subsequent heating of the photoresist at a temperature at or above the surface Tg causes the surface of the photoresist to flow and smooth out the surface irregularities. The flow of the photoresist can be controlled on a microscopic scale based on the parameters and materials selected for the process. That is, the depth of penetration of the solvent in the surface of the photoresist can be controlled and limited to the depth of the surface of irregularities such that subsequent flow of the exposed areas renders the surface smooth. It is preferred that the temperatures selected for selectively flowing the photoresist surface are below the Tg of the bulk photoresist or are for a time such that flow of the bulk photoresist is minimal and does not deleteriously affect the targeted critical dimension of the photoresist feature. The temperature used for heating the photoresist surface may be constant or variable. Typically, the temperatures used for flowing the photoresist surface are from about 20 degrees C to about 250 degrees C. The total time and temperature used is dependent on the photoresist thermal properties and the determination thereof is well within the skill of those in the art to optimize. The particular components of the non-reactive vapor are selected by their ability to form a vapor at vapor forming conditions and their ability to penetrate

into the surface of the photoresist. Accordingly, the vapor can be a single material or a mixture generated from a solid, liquid or gas. Preferably, the vapor is a solvent or co-solvent for the polymer used in the photoresist. However, in some cases, it is desirable and advantageous to employ a material with which at least one of the components in the photoresist is only marginally soluble or miscible. It has been found that this will help control the extent of vapor penetration and subsequent plasticization. The solid, liquid and/or gas materials are exposed to a temperature and/or pressure sufficient to maintain the selected material in its vapor phase. The range of vapor pressures suitable for use in the present invention is in a range from about 1 atm to about 760 atm. In practice, preferred materials are liquids with a boiling point less than 200.degree. C. at standard atmospheric pressure. Examples of suitable solvents for forming the vapor include, but are not limited to, ketones such as acetone, methyl ethyl ketone, and esters such as butyl acetate, ethyl lactate and propylene glycol methyl ether acetate. Other materials suitable for use in the present invention will be apparent to one skilled in the art in view of this disclosure. Exposure to the vapor may be limited by time and/or by concentration (vapor pressure). The effect of such permeation and penetration into the surface of the photoresist will be to selectively lower the Tg at the surface via a plasticization of the polymer chains. Solvent plasticization is a well-known phenomena known to those skilled in the art to lower the Tg of polymers. This in turn will allow the polymer chains to flow in the vapor-permeated region at a lower temperature than that of the bulk resist.

Hallock et al fails to teach the use of a supercritical fluid after development. Verhaverbeke teaches to add a step of using a supercritical fluid to dry the surface of the substrate/ pattern after development. The supercritical fluid includes, but are not limited to,

carbon dioxide, xenon, argon, helium, krypton, nitrogen, methane, ethane, propane, pentane, ethylene, methanol, ethanol, isopropanol, isobutanol, cyclohexanol, ammonia, nitrous oxide, oxygen, silicon hexafluoride, methyl fluoride, chlorotrifluoromethane, water, and combinations thereof. Furthermore <u>Supercritical</u> fluids and/or dense fluids, such as carbon dioxide, may be used to advantage in processing a variety of materials used in semiconductor applications. For example, <u>supercritical</u> fluids and/or dense fluids are useful in processing of porous low-k materials. Examples of porous low-k materials include organosilanes or organosiloxanes, such as Black Diamond.TM., available from Applied Materials, Inc. of Santa Clara, Calif.; organo-silicate-glass (OSG); tetraethylorthosilicate (TEOS); methylsilsesquioxane (MSQ); hydrido silsesquioxane (HSQ); MSQ-HSQ copolymers; silsesquioxane HOSP; other Si-containing material; other porous polymers; and any other suitable material. Preferably, the porous low-k materials comprise an organosilanes or organosiloxanes. Depending on the application, other optional components, such as co-solvents, surfactants, chelating agents, reactants, and combinations thereof, may be used in conjunction with the supercritical fluid and/or dense fluid. Examples of co-solvents include, but are not limited to, alcohols, halogenated solvents, esters, ethers, ketones, amines, amides, aromatics, aliphatic hydrocarbons, olefins, synthetic and natural hydrocarbons, organosilicones, alkyl pyrrolidones, paraffins, petroleum-based solvents, other suitable solvents, and mixtures thereof. The co-solvents may be miscible or immiscible with the supercritical fluid and/or dense fluid. Examples of chelating agents include, but are not limited to, chelating agent containing one or more amine or amide groups, such as ethylenediaminetetraacetic acid (EDTA), ethylenediaminedihyroxyphenylacetic acid (EDDHA), ethylenediamine, or methyl-formamide or other organic acids, such as iminodiacetic acid or

oxalic acid. The term "surfactants" as used herein includes compounds have one or more polar groups and one or more non-polar groups. It is believed that the surfactants help alter the interfacial characteristics of the supercritical fluid and/or dense fluid. Examples of reactants include, but are not limited to silicon-containing compounds, oxidizing agents, carbon-containing compounds, other reactants, and combinations thereof. These are listed as plasticizers in the instant specification.

Given the teachings of the references, it would have been obvious to one of ordinary skill in the art to prepare the material of Hallock et al choosing to dry the pattern/ substrate post development of Verhaverbeke with reasonable expectation of achieving a pattern having reduced line edge roughness.

Response to Arguments

3. Applicant's arguments filed 10/1/2007 have been fully considered but they are not persuasive. Applicant has amended the claims to strike the limitation that a plasticizer in supercritical fluid is applied to the resist to read that the glass transition temperature of the resist is lowered. On page 6, lines 8-11 of the instant specification, it is taught that the application of a plasticizer as previously claimed actually lowers the Tg of the resist, therefore the references of record do teach a step of applying a plasticizer as previously discussed (a position affirmed by the BPAI on 8/8/2007), which would inherently lower the Tg of the material as it would be expected to have that affect. Therefore it is the position of the examiner that the references of record do in fact teach a process that would lower the Tg of the material given the teachings of the references and those found in the instant specification despite the reference not specifically saying that their aim is to lower the Tg.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Amanda C. Walke whose telephone number is 571-272-1337. The examiner can normally be reached on M-R 5:30-4.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Cynthia Kelly can be reached on 571-272-1526. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Amanda C Walke

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Primary Examiner
Art Unit 1795

ACW
December 22,2 007